PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2002-004985
(43)Date of publication of application : 09.01.2002

(51)Int.Cl. F02N 11/08
F02D 13/02
F02D 17/00
F02D 29/02
F02D 41/06
F02D 41/38
F02D 41/40
F02D 43/00
F02D 45/00
F02N 15/00

(21)Application number : 2000-181742
(22)Date of filing : 16.06.2000

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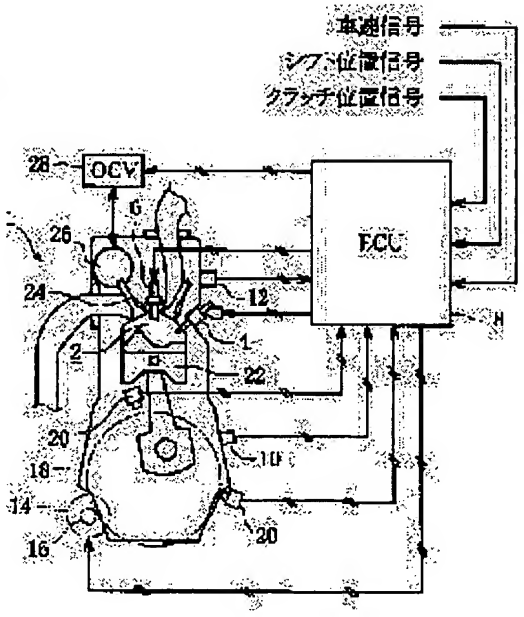
(54) STARTING DEVICE OF CYLINDER INJECTION TYPE INTERNAL COMBUSTION ENGINE

(57)Abstract:
PROBLEM TO BE SOLVED: To certainly start a cylinder injection type internal combustion engine without usual cranking.
SOLUTION: This starting device detects a cylinder in an expanding process based on signals from a crank angle sensor 10 and a cam angle sensor 12 in stopping an engine 1, and injects a predetermined fuel from a fuel injection valve 4 into the cylinder. For starting the engine 1, ignition is commanded to a spark plug 6 to cause combustion in the expanded cylinder, and the starting is performed only by the combustion pressure. The starting device has a failsafe function of completing the starting by preventing operation of a starter 14 when the starting of the engine 1 is successful or auxiliarily operating the starter 14 when the starting is incomplete.



LEGAL STATUS

[Date of request for examination] 26.03.2003
[Date of sending the examiner's decision of rejection]
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]
[Date of final disposal for application]
[Patent number]

* NOTICES *

CLAIMS

[Claim(s)]
[Claim 1] A cylinder-injection-of-fuel mold internal combustion engine which can inject a direct fuel to a combustion chamber characterized by providing the following A motor for carrying out cranking of said internal combustion engine A cylinder detection means to detect a cylinder which is in an expansion stroke after operation of said internal combustion engine has stopped An injection control means which injects a fuel in a cylinder in said detected expansion stroke A start-up means to make combustion occur and to start said internal combustion engine in a cylinder in said expansion stroke, and a motor control means which controls actuation of said motor according to a start-up condition of said internal combustion engine by said start-up means
[Claim 2] A cylinder-injection-of-fuel mold internal combustion engine with a function which injects a direct fuel to a combustion chamber while being carried in vehicles characterized by providing the following and driving vehicles An operational status detection means to detect operational status of vehicles An automatic-stay means to stop said internal combustion engine automatically when a predetermined condition precedent is satisfied based on said detected operational status An injection control means which detects a cylinder in an expansion stroke and injects a fuel in the cylinder when operation of said internal combustion engine is suspended by said automatic-stay means A start-up means to make combustion occur within a cylinder in said expansion stroke, and to start said internal combustion engine automatically when predetermined start-up conditions are satisfied based on said operational status after a halt by said automatic-stay means, a motor for carrying out cranking of said internal combustion engine, and a motor control means that controls actuation of said motor according to a start-up condition of said internal combustion engine by said start-up means
[Claim 3] Starting system of a cylinder-injection-of-fuel mold internal combustion engine according to claim 1 or 2 characterized by having further an adjustable valve timing device which makes adjustable a valve-opening stage of said internal combustion engine's exhaust valve, and a valve-opening control means which controls actuation of said adjustable valve timing device in order to delay a valve-opening stage of an exhaust valve about a cylinder which is in said expansion stroke at least.

[Translation done.]

* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] This invention relates to the starting system suitable for starting a cylinder-injection-of-fuel mold internal combustion engine.
[0002]
[Description of the Prior Art] As technology about this kind of cylinder-injection-of-fuel mold internal combustion engine's start up, an internal combustion engine's start method indicated by JP,11-159374,A, for example is mentioned. This well-known start method tends to inject a fuel to the combustion chamber which has taken the expansion (activity) stroke on the occasion of an internal combustion engine's start up, and tends to obtain power required for an internal combustion engine's start up by that combustion energy. The fuel injected by an internal combustion engine's idle state specifically tends to be lit, and by starting only by the explosive power, cranking by the starter motor is omitted thoroughly, or a 1-3 revolution grade, after carrying out, a fuel tends to be injected and tends to be lit, cranking time amount tends to be shortened, and it is going to reduce power consumption for cranking by the starter motor.
[0003]
[Problem(s) to be Solved by the Invention] However, after this kind of internal combustion engine has suspended that operation according to a predetermined heat cycle the place in which steady operation is possible, the flow and pressure requirement in the cylinder in an expansion stroke is in the condition of having lacked relevance with a series of inhalation-of-air work and work of compression which were performed in the intake stroke and compression stroke before it. That is, if operation of an internal combustion engine is suspended, into a cylinder, the air filled up with and compressed will flow out out of a cylinder, and the cylinder internal pressure will fall. Even if it makes combustion form in the cylinder which is in an expansion stroke in such the condition, it is difficult to get the expansion work corresponding to an internal combustion engine's heat cycle from the combustion.
[0004] For this reason, if the combustion pressure obtained by the well-known start method becomes small as compared with the combustion pressure obtained by the usual no-load running, for example, a Taki telescopic internal combustion engine has it, it may be unable to overcome the compression pressure of the cylinder in other compression strokes, and may be unable to depress a piston. If it is in such a condition, since a piston cannot exceed a top dead center in the cylinder in a compression stroke, it cannot be said as what can guarantee an internal combustion engine's positive start up any longer. The room of the part which is performing cranking by the starter motor from an internal combustion engine's idle state by the start method which injects a fuel on the other hand after performing cranking of 1 - 3 revolution degree, and still power-saving is large.
[0005] Then, this invention offers the starting system of the cylinder-injection-of-fuel mold internal combustion engine which can also hold down consumption of power to the minimum while collateralizing the soundness of the start up in an internal combustion engine.
[0006]
[Means for Solving the Problem] Although starting system (claim 1) of a cylinder-injection-of-fuel mold internal combustion engine of this invention puts an internal combustion engine into operation by detecting a cylinder which is in an expansion stroke after operation of an internal combustion engine has stopped, injecting a fuel in that cylinder, and making combustion occur, it shall control actuation of a motor for cranking according to that start-up condition at this time.
[0007] If it can be made to detonate completely only by the combustion pressure when combustion is made to occur in a cylinder which is in an expansion stroke by an internal combustion engine's idle state as mentioned above, it may happen, also when start up becomes imperfect with lack of combustion pressure. For this reason, especially if a start-up

condition is a success (high-order detonation) in control of a motor, it is not necessary to operate a motor, on the other hand, when a start-up condition is imperfect, a motor is operated, and start up is ensured by adding cranking. In addition, since cranking by starting system of this invention assists force in which combustion gas depresses a piston, as compared with cranking from the perfect idle state, its power used is very small.

[0008] Moreover, in the case of a cylinder-injection-of-fuel mold internal combustion engine carried in vehicles, starting system (claim 2) of this invention detects operational status of vehicles, and when a predetermined condition precedent is satisfied based on the operational status, it suspends operation of an internal combustion engine automatically. When stopping operation automatically, especially starting system of this invention detects a cylinder in an expansion stroke, and injects a fuel in the cylinder. Then, if predetermined start-up conditions are satisfied based on operational status, while making combustion occur within a cylinder in that expansion stroke and starting an internal combustion engine automatically, actuation of a motor is controlled according to that start-up condition.

[0009] As mentioned above, if a fuel is injected in a cylinder in an expansion stroke when operation of an internal combustion engine is suspended automatically, prompt start up will be attained only by lighting, when start-up conditions are satisfied after this. If it has detonated completely only by combustion pressure by this ignition, it is not necessary to operate a motor, and only by combustion pressure, when a start-up condition becomes imperfect, start up more positive than operate a motor and adding cranking is attained.

[0010] Furthermore, to starting system of a cylinder-injection-of-fuel mold internal combustion engine of this invention, an adjustable valve timing device about an exhaust valve and its valve-opening control means can be included further (claim 3), and the valve-opening control means is controllable in order to delay a valve-opening stage of an exhaust valve about a cylinder which is in an expansion stroke at least. In this case, it is controlling valve opening of an exhaust valve until a piston of a cylinder in an expansion stroke reaches a bottom dead point, and efficient expansion work of combustion gas is promoted.

[0011]

[Embodiment of the Invention] As 1 operation gestalt of this invention, the starting system of a cylinder-injection-of-fuel mold internal combustion engine carried in vehicles is explained. However, the use of the internal combustion engine with which this invention is applied is not limited to vehicles. If drawing 1 is referred to, the engine 1 which is the internal combustion engine of a cylinder-injection-of-fuel mold is equipped with the fuel injection valve 4 which can inject a direct fuel in the cylinder 2, i.e., a combustion chamber. Moreover, it has the layout of the serial 4-cylinder mold which sees an engine 1 by the crank angle and explodes at equal intervals for every 180-degreeCA, and the fuel injection valve 4 and the ignition plug 6 are formed in each cylinder of the.

[0012] Electronics control of the stage of the fuel injection to each cylinder and ignition is carried out with the electronic control unit (ECU) 8, and, specifically, the fuel injection valve 4 and ignition plug 6 which were mentioned above operate based on the injection pulse signal or ignition signal outputted from ECU8. The crank angle sensor 10 and the cam angle sensor 12 are attached in the engine 1, and since ECU8 judges injection and ignition timing proper, it can perform data processing using the crank angle signal inputted from the crank angle sensor 10. Moreover, ECU8 distinguishes the cylinder in a compression stroke, and controls fuel injection and ignition timing by operation mode which can distinguish the cylinder which is in a specific stroke using the cam angle signal inputted from the cam angle sensor 12 in addition to a crank angle signal, for example, injects a fuel by the compression stroke.

[0013] Furthermore, using the function of cylinder distinction mentioned above, ECU8 can detect the cylinder in an expansion stroke, when an engine 1 suspends operation, and it can memorize the detected cylinder (cylinder detection means). The starter 14 for cranking (motor) is attached to the engine 1, for example, this starter 14 can engage and drive a pinion 16 to the ring wheel formed in the periphery of a flywheel 18, and cranking of the engine 1 can be carried out. In addition, a pinion 16 may be a type which always gears with flywheel starter gear.

[0014] Moreover, the blade (not shown) of equiangular width of face is formed in the hoop direction at intervals of the fixed angle, equally (for example, 30 degrees), on the periphery of a flywheel 18, only the angle (for example, 15 degrees) of the one half shifts a phase mutually, and two piston position sensors 20 are arranged by the angle width of face and its mounting gap of these blades at it. With passage of each blade, these pistons position sensor 20 can form the signal of ON or OFF, and can input it into ECU8.

[0015] When an engine 1 suspends operation, it can detect in which location (degreeATDC, **BTDC) at counting the standup and falling of ON/OFF signal, for every cylinder, the piston 22 saw ECU8 by the crank angle, and stopped it just before that. In addition, according to the observation which the artificer of this invention etc. performed, the property of the piston 22 of the cylinder which is usually in an expansion stroke from balance of the cylinder internal pressure of a compression cylinder and an expansion cylinder with the engine 1 of a 4-cylinder mold, for example that the frequency stopped in the location near the 100-degreeATDC is high is clear.

[0016] In addition to this, the engine 1 is equipped with the adjustable valve timing device 26 whose modification of the valve-opening stage of an exhaust valve 24 is enabled. this adjustable valve timing device 26 carries out the variation rate of the phase of a cam shaft (neither is illustrated) for example, using a hydraulic actuator -- making -- predetermined within the limits -- a valve-opening stage -- the angle of delay -- or a tooth lead angle can be carried out. The feeding-and-discarding way of actuation oil pressure is connected to the hydraulic actuator of the adjustable valve timing device 26 through the oil control valve 28, and the oil control valve 28 can switch the direction of feeding and discarding of the actuation oil pressure to a hydraulic actuator, and can make the actuation to the direction of the angle of delay, or the direction of a tooth lead angle perform. Moreover, concrete actuation of the oil control valve 28 is realizable with switch control of the spool location which used the solenoid, and ECU8 is outputting the rate of control duty to the solenoid, and has the function to perform the angle of delay of a valve-opening stage, or tooth-lead-angle control concretely.
[0017] Moreover, information, such as a clutch position signal showing treading in or discharge of the vehicle speed signal which can collect information from various kinds of sensors since the operational status of vehicles is detected, for example, is inputted from a speed sensor, the shift-position signal inputted from a shift-position sensor, and the clutch pedal inputted from a clutch location sensor, can input ECU8 into ECU8 (operational status detection means).
[0018] Although the above is 1 operation gestalt at the time of applying the starting system of this invention to the engine 1 for vehicles, the starting system of this invention has other configurations about the control function of ECU8 further.
[0019]
[Example] A concrete example is given to below and start up of the engine 1 using the starting system of this invention is explained to details. Moreover, the concrete configuration of others concerning the starting system of this invention also becomes clear through the following explanation. Drawing 2 shows the flow chart of the start-up control routine which ECU8 should perform, and ECU8 performs start-up control of an engine 1 in the procedure in alignment with this flow. The flow of drawing 2 is positioned as a Maine control routine after operation of an engine 1 was suspended, and contains two subroutines R1 and R2 in the middle of the step.
[0020] In this example, automatic idle halt / start-up system is built into ECU8, and ECU8 can judge formation of a predetermined condition precedent and start-up conditions based on the operational status of the vehicles mentioned above. For example, when a shift position has the vehicle speed neutrally by 0 and treading in of clutch pedal is canceled, ECU8 judges with formation of a condition precedent. When a condition precedent is satisfied, ECU8 stops fuel injection and ignition, and stops an engine 1 automatically. In addition, it is also possible to carry out the current update of the parameter which should be detected, and to use these for the judgment of a condition precedent.
[0021] ECU8 operates the adjustable valve timing device 26 further mentioned above when suspending operation of an engine 1, and sets the valve-opening stage of an exhaust valve 24 to the angle-of-delay side (valve-opening control means). In addition, when a hydraulic actuator can operate certainly, you may carry out after a halt of an engine 1. When automatic stay of such an engine 1 is performed, or when an operator turns OFF an ignition switch, ECU8 starts activation of the start-up control routine of drawing 2 .
[0022] First, when it judges whether the rotational speed of an engine 1 became below the predetermined value Ne0 (for example, 30rpm, min-1) in step S1 and this judgment is materialized (Yes), ECU8 regards it as what the engine 1 stopped, and progresses to step S2. At step S2, ECU8 judges whether the predetermined timer after a halt has stopped the count (= 0), when having stopped, progresses to step S3 and starts actuation of the timer after a halt. In addition, an after [this halt] timer and various kinds of timers mentioned later can be incorporated for example, in ECU8, and can count elapsed time with that starting.
[0023] In the following step S4, ECU8 judges whether the predetermined timer after injection has stopped the count (= 0). Since the timer after this injection is not yet operating after suspending operation of an engine 1, ECU8 progresses to the following step S5, and judges formation of start-up conditions. The input of the automatic start-up conditions after performing automatic stay mentioned above as this start-up condition, and the ON signal of an ignition switch is assumed. In addition, the start-up conditions in automatic idle halt / start-up control are satisfied, when it gets into clutch pedal in this condition on the assumption that there is a shift position neutrally.
[0024] Since it is thought that it is necessary to start an engine 1 immediately when formation of start-up conditions is judged at this event (Yes), ECU8 bypasses a subroutine R1, progresses to step S11, operates a starter 14 promptly, and starts cranking. This is for satisfying a quick start-up demand after a halt of an engine 1. On the other hand, if immediate start-up conditions are not satisfied at step S5, it progresses to the subroutine R1 for (No) and halt after treatment.
[0025] Drawing 3 shows the details of subroutines R1 and R2 mentioned above. If ECU8 progresses to a subroutine R1 from step S5 of a main routine, it will judge whether predetermined time has passed after a halt of an engine 1 at step

S6. If this judgment can be made from the count of the timer after a halt mentioned above and predetermined time has not passed, (No) ECU8 carries out the return of the main routine, and before that progress repeats the above-mentioned processing (steps S1-S6). In addition, since the timer after a halt has already operated, in the case of a repeat, step S3 is bypassed.

[0026] If progress of predetermined time is accepted at step S6 (Yes), ECU8 will order it fuel injection to the cylinder which progressed to step S7 and has stopped by the expansion stroke, and will start actuation of the timer after injection at step S8. In addition, since ECU8 has already detected the cylinder in an expansion stroke at this event, an injection signal is supplied to the fuel injection valve 4 corresponding to that cylinder, and a fuel is injected actually (injection control means). More preferably, ECU8 can ask accuracy for the air content in a cylinder from the detected piston location, and can carry out metering of the fuel which should be injected appropriately.

[0027] although ECU8 judges whether predetermined time passed after ignition in the following step S9, since it is not yet lighting at this event -- (No) -- the return of the main routine is carried out as it is. Then, if ECU8 returns to a main routine, since the injection timer has already operated, it will progress to step S12 from step S4. At step S12, it judges again whether start-up conditions are satisfied, and the loop to the above-mentioned step S1 - step S12 (S1, S2, S4, S12) is only repeated until start-up conditions are satisfied.

[0028] Then, ECU8 progresses to the subroutine R2 for start-up processing only after start-up conditions are satisfied. In a subroutine R2, ECU8 judges whether predetermined time passed after injection of a fuel at step S13. This predetermined time can be set up as a duration for ensuring that evaporation after injection of a fuel. When this predetermined time has not passed, (No) and ECU8 end a subroutine R2, progress to step S11 of a main routine, and perform cranking by the starter 14. Decision at such a step S13 is for expecting the evaporation time amount of a fuel and preventing a flame failure beforehand.

[0029] When it is admited that predetermined time has passed at step S13 (Yes), it progresses to step S14, and it judges whether ignition was performed or not from the counted value of the timer after ignition. At this event, it is counted value =0, and since it can be judged as ignition before, ECU8 progresses to step S15, and orders it ignition. This command is made to the cylinder in the expansion stroke which already injected the fuel, and an ignition signal is specifically outputted to an ignition plug 6. In addition, if it takes into consideration that cylinder internal pressure is falling by halt of operation, in order to secure sufficient heat energy for firing at this time, it is desirable to perform multiplex ignition.

[0030] Next, it judges whether ECU8 started actuation of the timer after ignition at step S16, it progressed to step S9, and predetermined time passed after ignition. (No) and ECU8 carry out the return of the main routine, go into a subroutine R2 from step S12 again, bypass steps S15 and S16, and repeat decision of step S9 until this predetermined time passes (step S14= No).

[0031] If it judges that predetermined time passed after ignition, ECU8 will judge whether the engine speed is over the predetermined value Nes at step S10. This predetermined value Nes is set up as a threshold for judging whether start up of an engine 1 was successful, and it judges as that whose start-up condition is a success if the rotational speed of an engine 1 is over this predetermined value Nes, and on the other hand, if ECU8 is below the predetermined value Nes, it can judge it as what is in an imperfect start-up condition.

[0032] In addition, although not clearly shown by the flow chart of drawing 2 , if a piston 22 begins to move by step S15 after ignition, ECU8 will order it injection also about the cylinder which is in a compression stroke then, and will order it ignition further in the top dead center. An engine 1 starts without complete explosion's happening in the cylinder which suited the compression stroke, and performing the usual cranking by this, at the time of a halt of an engine 1.

[0033] As a result of judging a start-up condition, when imperfect, (No) ends a subroutine R2, and return and ECU8 progress to step S11 at a main routine, and it operates a starter 14. On the other hand, when a judgment result is a success (Yes), since ECU8 carries out the return of the main routine, a starter 14 does not operate. Even if it is in the case of which [above], when an engine 1 starts and rotational speed exceeds the predetermined value Nes, ECU8 resets various kinds of timers which shifted to step S17 and were mentioned above from step S1 of a main routine, respectively, and ends activation of a start-up control routine.

[0034] By performing the start-up control routine mentioned above, when putting an engine 1 into operation, in the cylinder in an expansion stroke, ECU8 makes combustion occur and starts an engine 1 (start-up means). At this time, ECU8 controls actuation of a starter 14 according to the judgment result in step S11, i.e., the start-up condition of an engine 1, (motor control means).

[0035] Therefore, when it succeeds in start up only by the combustion pressure in the cylinder in an expansion stroke according to the starting system of this example, start up of an engine 1 is performed, without operating a starter 14. On the other hand, only by the combustion pressure in a cylinder, when start up becomes imperfection, cranking by the

starter 14 can be added auxiliary, for example, and start up of an engine 1 is attained only with the minimum power used. This assistance does not require excessive torque like cranking which it is only sufficient for to carry out to the degree to which the cylinder in a compression stroke exceeds a top dead center, and is performed by the usual idle state. In addition, although the start-up condition is judged from the engine speed in the one example, you may judge using other detection parameters.

[0036] Moreover, as mentioned above, if the valve-opening stage of an exhaust valve 24 is beforehand set to the angle-of-delay side, while the piston 22 is depressed by the expansion stroke, an exhaust valve 24 can be closed, and sudden lowering of the combustion pressure in the inside of the expansion stroke will be prevented. Efficient expansion work of combustion gas can be promoted by this, and it can contribute to a success of start up only by combustion pressure.

[0037] Although idle stop vehicles are used in the above-mentioned example, you may be the vehicles (for example, hybrid vehicles) which suspend and start an engine automatically. Moreover, although actuation of automatic idle halt / start-up control system of vehicles is doubled and explained, the starting system of this invention does not necessarily require coordination with such a control system about the engine 1 for vehicles. When making it restart after it follows, for example, the operator of vehicles stops an engine 1, the start-up control routine mentioned above can be performed independently, and an engine 1 can be put into operation.

[0038] The operation gestalt of this invention is not restricted to the engine 1 mentioned as an example, but may have other cylinder layouts, and may be a single-cylinder mold. Moreover, it cannot be overemphasized that replacement is suitably possible in the configuration of a concrete member or components in other desirable modes about the operation gestalt of this invention.

[0039]

[Effect of the Invention] The starting system (claim 1) of the cylinder-injection-of-fuel mold internal combustion engine of this invention makes an internal combustion engine's start up a positive thing for a short time. Moreover, large power saving becomes possible by using the motor only for start-up fail-safe. Moreover, since the starting system (claim 2) of the cylinder-injection-of-fuel mold internal combustion engine of this invention guarantees the quick nature and soundness of start up, it can cooperate with automatic-stay / start-up control of the internal combustion engine carried in vehicles suitably, and it contributes also to the object achievement of the fuel consumption reduction greatly.

[0040] Furthermore, if the starting system of this invention includes the configuration about valve-opening control (claim 3), can be rationally assisted with an internal combustion engine's start up by the work.

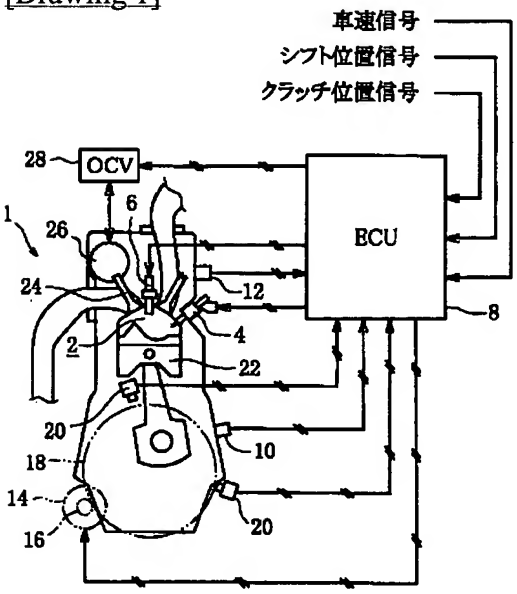
[Translation done.]

* NOTICES *

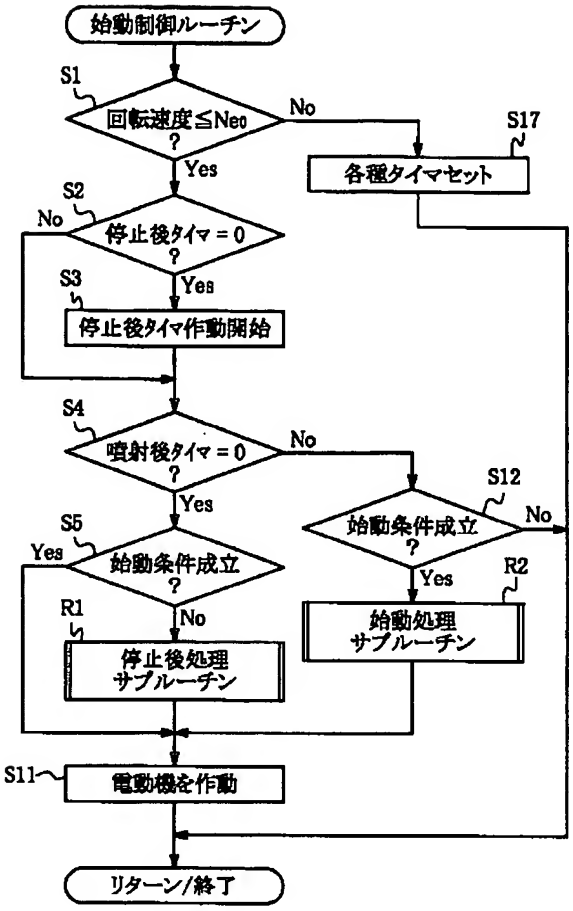
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

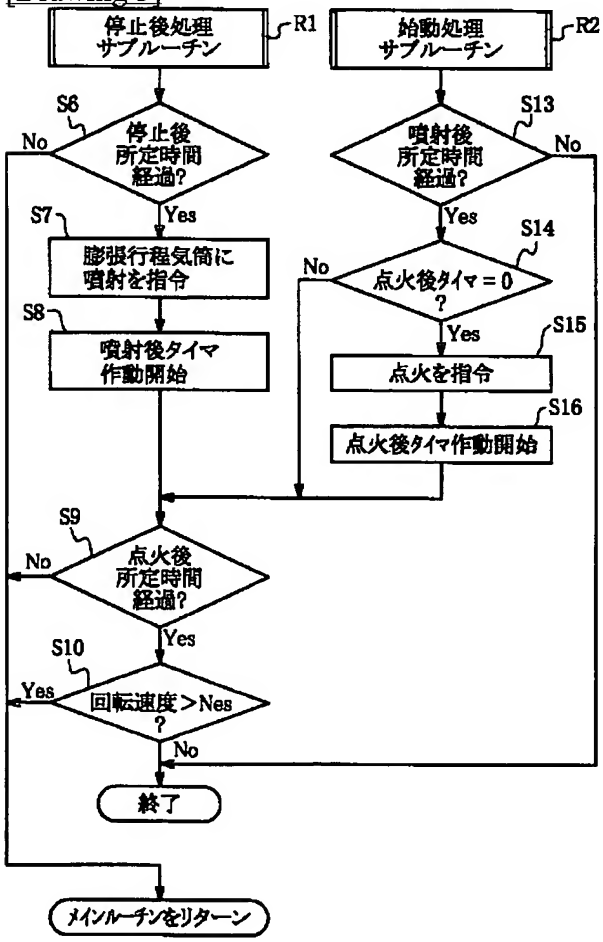
[Drawing 1]



[Drawing 2]


始動制御ルーチン
S1
回転速度≦Ne0 ?
No
S17
各種タイマセット
Yes
S2
No
停止後タイマ = 0 ?
Yes
S3
停止後タイマ作動開始
S4
噴射後タイマ = 0 ?
No
S12
始動条件成立 ?
No
Yes
S5
Yes
始動条件成立 ?
R2
始動処理 サブルーチン
R1
No
停止後処理 サブルーチン
S11
電動機を作動
リターン/終了

[Drawing 3]


停止後処理 サブルーチン
R1
始動処理 サブルーチン
R2
S6
停止後 所定時間 経過?
No
Yes
S13
噴射後 所定時間 経過?
No
Yes
S7
膨張行程気筒に 噴射を指令
S14
No
点火後タイマ = 0 ?
S8
噴射後タイマ 作動開始
Yes
S15
点火を指令
S16
点火後タイマ作動開始
S9
No
点火後 所定時間 経過?
Yes
S10
Yes
回転速度＞Nes ?
No
終了
メインルーチンをリターン

[Translation done.]